

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
27 September 2001 (27.09.2001)

PCT

(10) International Publication Number
WO 01/71655 A1

(51) International Patent Classification⁷: **G06K 15/00**

(21) International Application Number: PCT/US01/08139

(22) International Filing Date: 14 March 2001 (14.03.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/527,179 16 March 2000 (16.03.2000) US

(71) Applicant: **LEXMARK INTERNATIONAL, INC.**
[US/US]; Intellectual Property Law Dept., 740 West New Circle Road, Lexington, KY 40550 (US).

(72) Inventor: **COOK, William, Paul**; 1143 Rockbridge Road, Lexington, KY 40515 (US).

(74) Agent: **SANDERSON, Michael, T.**; Lexmark International, Inc., Intellectual Property Law Dept., 740 West New Circle Road, Lexington, KY 40550 (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.



WO 01/71655 A1

(54) Title: OPTICAL SENSOR ARRANGEMENT FOR START OF SCAN DETECTION AND IMPROVED VERTICAL BEAM ALIGNMENT RANGE

(57) Abstract: A laser beam position sensing arrangement using two similar sensors where, instead of the first sensor being aligned normal to the beam scan path, the angle which bisects the two sensors is aligned normal to the beam scan path. The average of times T1 and T2 at which the laser beam is incident the respective sensors is used for the horizontal or start of scan value, and the difference (T2-T1) is proportional to the vertical or process direction value. From the difference between the two determined times, the longitudinal beam position may be determined.

OPTICAL SENSOR ARRANGEMENT FOR START OF SCAN DETECTION
AND IMPROVED VERTICAL BEAM ALIGNMENT RANGE

BACKGROUND OF THE INVENTION

1. Field of the invention.

The present invention relates to image forming apparatus such as laser printers and more particularly to an arrangement for determining laser beam position.

2. Description of the related art.

5 An in-line color laser image printing process where the media passes through four color developing stations in series will print the same speed as monochrome. The photo conductive drum exposures typically occur on all four colors at the same time. Both process and scan direction alignment of the four color developing stations is critical. The process location of each scanning laser beam must overlap to prevent
10 color offset in the process direction. If one beam is out of synchronization with the others, the image in the corresponding color will be misaligned relative to the remaining color components, and the resulting image blurred. Each color should have an adjustment to correct for process direction misalignment because each color has a scanning laser beam following a separate optical path. Thermal changes will cause
15 misalignment so the adjustment should be performed real time and not be just a one time manufacturing adjustment

It is possible to utilize a sensor arrangement for two dimensional beam detection known as PSD or Position Sensitive Detection. In such an arrangement, two optical sensors are used. One functions as a start of scan sensor to detect the horizontal scan beam location. A second sensor may be added at an angle to the first, and the time delay between the two sensors used to determine the vertical beam position location or so-called process direction. Firmware processes this information and makes appropriate adjustments in the raster image. Such an arrangement has a disadvantage in that the second sensor must be longer than the first to achieve the same vertical
20 detection range. If the second sensor is offset by an angle of 45 degrees, the second sensor will be nearly 1.5 times longer than the first, which will be more expensive and
25 may not be feasible.

It is highly desirable to implement an in-line process using four scanning lasers. What is needed in the art is a sensor arrangement which is capable of a full PSD function with reasonable expense.

5

SUMMARY OF THE INVENTION

The invention provides apparatus for determining the coordinates of the location of a laser beam utilizing first and second laser light sensitive sensors which are disposed obliquely to one another.

The invention comprises, in one form thereof, a color printer having multiple laser printheads, each employing a laser beam which executes a scan pattern of repeated transverse scans along a corresponding line to form image information, and laser beam position sensing arrays for each printhead synchronizing operation of the printheads. Each position sensing array includes first and second elongated laser light sensitive sensors extending obliquely to one another and to the corresponding laser scan line.

An advantage of the present invention is that sensor length and cost are reduced, and/or the effective range of process detection is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

20 The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

25 Fig. 1 is a generalized cross-sectional view of an embodiment of a laser printer having color capability utilizing four laser printheads in which the present invention finds particular utility;

Fig. 2 is a simplified front view of one laser beam position sensing arrangement according to the present invention;

30 Fig. 3 is a simplified top view of the sensing arrangement of Fig. 2 and including a laser and rotating mirror; and

Fig. 4 is a schematic illustration of circuitry for determining laser beam positions utilizing the sensing arrangement of Figs. 2 and 3.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

5

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and particularly to Fig. 1, there is shown an embodiment of a laser printer having, for example, four laser printheads such as 12, 14, 16 and 18 aligned along the intermediate transfer member in the form of image transfer belt 20. Each of the printheads 12, 14, 16, and 18 develops an image on a corresponding photo conductive drum such as 22. Next, the image is developed with one of four-color toners. i.e. black, magenta, cyan, or yellow, and transferred successively onto the image transfer belt 20. Finally, the image is transferred to a substrate (paper or transparency) at nip 24, fused and processed out of the printer as indicated by the arrow 26. Each laser printhead executes a scan pattern of repeated transverse scans along the corresponding photo conductive drum as that drum rotates and includes a beam position determining arrangement of the type illustrated in Figs. 2 and 3.

In Fig. 2, a pair of optical sensors 28 and 30 extend obliquely to one another, each at an angle A to the bisector 36. The plane of Fig. 3 is orthogonal to that of Fig. 2. A beam 32 from laser 38 impinges rotating mirror structure 40 and sweeps in a repeated transverse scan path 34 as mirror structure 40 rotates. Laser beam 32 progresses along the transverse path 34 and is incident sensor 28 at time T1 and later impinges sensor 30 at time T2. The direction of scan is generally perpendicular to the bisector 36. After scanning past the sensors, the beam exits the printhead, impinges a photo conductive drum such as 22 and performs the image forming task. If, for example, the longitudinal (i.e., vertical or process direction) position of the scan line changes to that shown at 34', the beam impinges the sensor 28 at an earlier time T1' and strikes the second sensor 30 at a later time T2'. The reverse would result if the beam were raised.

The vertical sensitivity or change in signal vs. vertical position change depends on the angle (2A) between the sensors. Greater sensitivity can be achieved by increasing the angle, at the expense of lengthening both sensors or decreasing the vertical range.

The angle is chosen to achieve a balance between sensor length which is directly related to cost, detection range, and sensitivity or accuracy.

Fig. 4 illustrates schematically the electrical circuitry for two laser printheads, each employing a laser beam which executes a scan pattern of repeated transverse scans along a corresponding line to form image information. There are two laser beam position sensing arrays for synchronizing operation of the printheads. Each position sensing array comprises first and second elongated laser light sensitive sensors 28 and 30, and 52 and 54 extending obliquely to one another and to the corresponding laser scan line, either 34 or 56. Circuit 46 responds to the time delay between the beam striking the first sensor 28 and the second sensor 30 to determine the longitudinal (process direction) coordinate of beam 34. Electrical circuit 42 responds to the average of the times required for the beam to reach the first and the second sensors 28 and 30 to determine a second beam coordinate. Typically, the second beam coordinate is an indication of when the beam reaches a start of scan location as indicated at 44. Similarly, the difference between the times T2 and T1 at which beam 56 impinges sensors 52 and 54 is determined at 58 and used to compute a measure of the longitudinal position of beam 56 as indicated at 62. The average of the two times T1 and T2 is determined at 60 and utilized to determine the start of scan 64. The beam positions 48 and 62 may be determined by a stored table look-up scheme. Such a table directly relates the time difference to the beam location for a particular sensor geometry. Other indications of position, even the time difference itself, may be employed. The two computed longitudinal beam positions 48 and 62 may then be compared by a comparator circuit 66 and a corrective action initiated at 68 if the compared positions differ by more than a predetermined or threshold amount. Replication of this circuitry may be made to accommodate the four printheads of Fig. 1. For example, one printhead may be taken as a reference and each of the others compared to and harmonized with this reference.

The harmonization or corrective action may involve changing the laser timing or the timing of the photo conductive drum such as 22. For example, assume one laser longitudinal scan line is too low as indicated by scan line 34'. Assume further that the drum surface on which the laser beam impinges is moving vertically relative to the sensors of Fig. 2. Under these conditions, the speed of the corresponding photo conductive drum may be slowed slightly to relocate the scan line 34' at the correct

location on the drum. With the same assumptions, commencing the laser beam scan earlier accomplishes the same correction.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. For 5 example, this invention may be incorporated in image forming apparatus other than a laser printer, to include electrophotographic devices, copy machines, laser scanners, etc. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or 10 customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. In an image forming apparatus, an apparatus for determining the longitudinal coordinate of a repetitively transversely moving light beam, comprising:

5 first and second elongated light sensitive sensors extending obliquely to one another and to the transverse direction of motion of the light beam; and

electrical circuitry responsive to the time delay between the beam impinging the first and the second sensors for determining said longitudinal coordinate.

10 2. The apparatus of claim 1, further comprising electrical circuitry responsive to the average of the times at which the beam impinges the first and the second sensors for determining the time at which the beam reaches a start of scan location.

3. The apparatus of claim 1, wherein a line which bisects the angle between the first and second sensors is generally perpendicular to the direction of transverse motion of the beam.

15 4. The apparatus of claim 1, wherein a change in the longitudinal coordinate causes one of:

the beam impinging the first sensor at an earlier time and the beam impinging the second sensor at a later time, or

the beam impinging the first sensor at a later time and the beam impinging the second sensor at an earlier time.

20 5. In an image forming apparatus utilizing a laser beam which executes a scan pattern of repeated transverse scans along a longitudinal line to form images on recording media, a process of determining the start of scan and the longitudinal beam position, comprising the steps of:

determining the time at which the laser beam reaches a first surface;

25 determining the time at which the laser beam reaches a second surface which second surface extends obliquely to the first surface;

averaging the two determined times to determine a start of scan reference time;

forming the difference between the two determined times;

deriving, from the difference between the two determined times, the longitudinal

30 beam position.

6. The process of claim 5, including the additional step of comparing the derived longitudinal beam position to other similarly derived laser beam positions.

7. The process of claim 6, including the further step of selectively correcting the apparatus to harmonize the compared beam positions.
8. A multi-color electrophotographic printer, comprising:
 - a plurality of laser printheads, each employing a laser beam which executes a scan pattern of repeated transverse scan lines to form image information; and
 - 5 a plurality of laser beam position sensing arrays for synchronizing operation of the printheads, each position sensing array comprising first and second elongated laser light sensitive sensors extending obliquely to one another and to a corresponding laser scan line.
- 10 9. The color printer of claim 8, wherein a line which bisects the angle between the first and second sensors of each array is generally perpendicular to the corresponding laser scan line.
- 10 10. The color printer of claim 8, wherein, further including electrical circuitry for determining the start of scan and the longitudinal beam position of each laser beam.
- 15 11. The color printer of claim 10, wherein, for each printhead, the electrical circuitry determines the time difference between the time at which the corresponding laser beam reaches the first sensor and the time at which the laser beam reaches the second sensor.
12. The color printer of claim 11, wherein the electrical circuitry averages the two
20 determined times to determine a start of scan for each printhead.
13. The color printer of claim 11, wherein the electrical circuitry computes, from the difference between the two determined times, the longitudinal beam position for each printhead.
14. The color printer of claim 13, wherein the electrical circuitry compares the
25 computed longitudinal beam positions and initiates a corrective action if the compared positions differ by more than a predetermined amount.

1 / 3

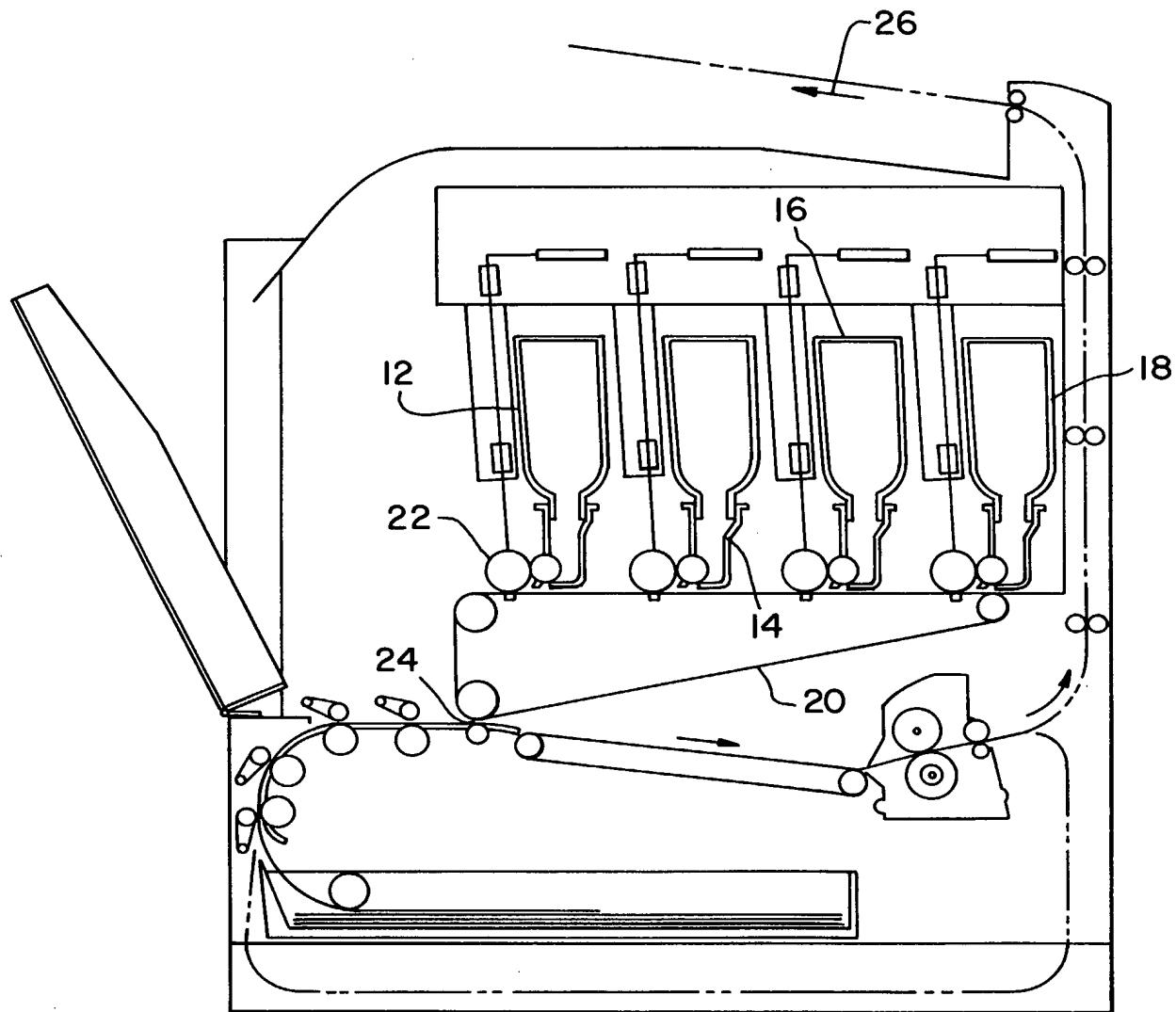


Fig. 1

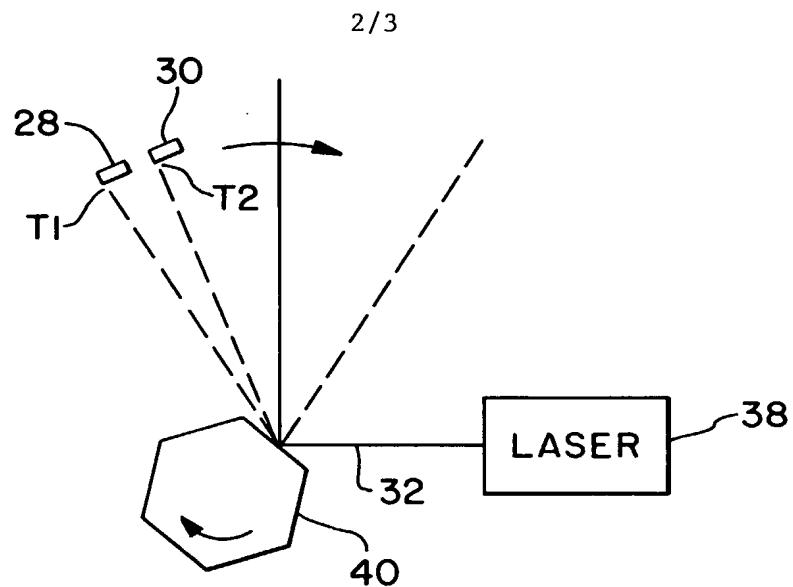


Fig. 3

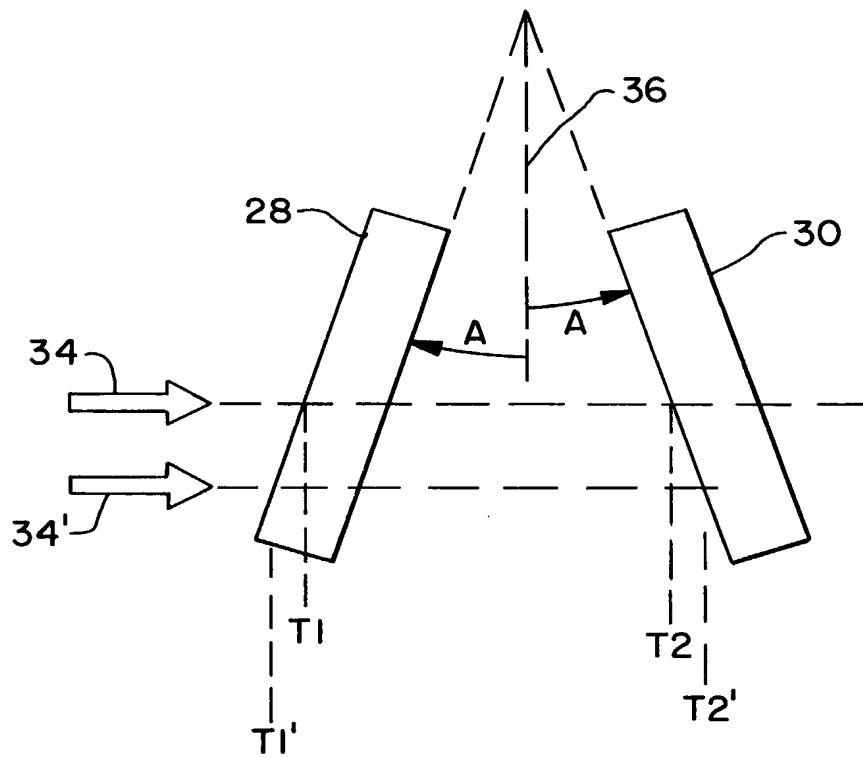


Fig. 2

3/3

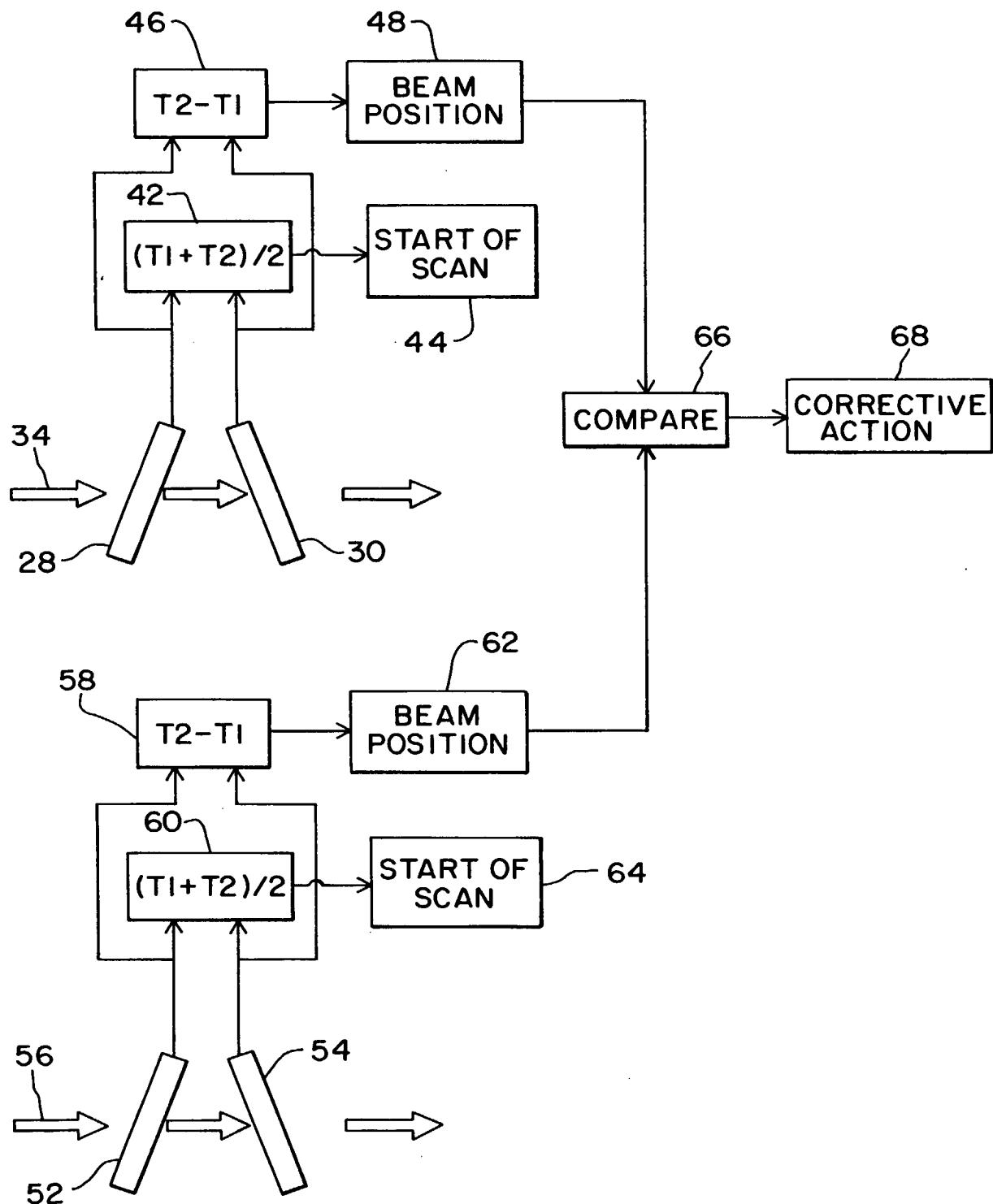


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/08139

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06K 15/00

US CL : 358/1.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 358/1.1, 1.5, 1.7, 1.12, 1.18; 347/116, 248

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,539,719 (MOTOI) 23 JULY 1996, fig. 4-6, column 1 line 30-40, column 4 line 30-67, column 8 line 1-45	3, 6, 7, 9
Y	US 5,583,557 (YAMAMOTO ET AL.) 10 DECEMBER 1996, Fig. 4, column 1 line 55-67, column 2 line 1-10, column 8 line 50-60	3, 6, 7, 9
X	US 5,982,402 (YOSHIKAWA ET AL.) 9 NOVEMBER 1999, column 2 line 1-22, column 10 line 50-67, column 11 line 1-30, column 8, 10-50, column 2 line 1-22, column 10 line 50-67, column 11 line 1-30, column 8 line 10-50	1, 4, 8, 10, 11, 13, 14
---		-----
Y	US 5,694,637 (YOSHINO ET AL.) 2 DECEMBER 1997, fig. 7, fig. 9, column 10, column 11 line 1-15	2, 3, 5, 6, 7, 9, 12
Y	US 5,844,591 (TAKAMATSU ET AL.) 1 DECEMBER 1998, fig. 7a, fig. 7b, column 10 line 45-68, column 11 line 1-25	3, 6, 7, 9
		2, 3, 5, 6, 7, 9, 12

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

03 June 2001 (03.06.2001)

Date of mailing of the international search report

10 AUG 2001

Name and mailing address of the ISA/US

Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Faxsimile No. (703)305-3230

Authorized officer

King Y. Poon

Telephone No. 703-305-0892

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/08139

Continuation of B. FIELDS SEARCHED Item 3: west
Search terms: laser, align\$5, sensor, printer, position, coordinate, regist\$6